BABYLONIAN ASTRONOMY AND CHRONOLOGY.

BABYLONIAN astronomy has been investigated during the last year successfully by the Rev. Joseph Epping and the Rev. J. N. Strassmaier, S.J., who have explained and annotated two Babylonian calendars of the years 123 B.C. and 111 B.C. in their publication "Astronomisches aus Babylon oder das Wissen der Chaldæer über den gestirnten Himmel" (Freiburg, Herder, 1889). They have succeeded in giving a satisfactory account of the Babylonian calculation of the new and full moon, and have for the first time identified by calculations the Babylonian names of the planets, and of the 12 zodiacal signs and twenty-eight normal stars which correspond to some extent to the 28 *nakshatras* of the Hindoos. In the following passages, translated from their book, we give the general results they have obtained, but for many interesting details we must refer the reader to the work itself.

Astronomical Summary.

In discussing the condition of the astronomy of the Babylonians we must rely upon the wider knowledge which we have now attained in regard to their acquaintance with celestial bodies. In this respect the Cuneiform Inscriptions before us furnish much that is new: other already more familiar material is confirmed through them and receives a documentary foundation. Before entering into details it will be well to call to mind how much of the Babylonian astronomy was previously historically established. The reader need not fear that we shall lay before him one by one the conclusions of authors who have written about the Babylonians with more or less trustworthiness, or that we shall subject their works to the light of criticism; we are fortunately spared this trouble. Rudolf Wolf, utilizing all sources bearing upon the subject, has made the most thorough studies, and has accomplished the task in so satisfactory a manner in his well-known "History of Astronomy,"[1] that we may accept his judgment with the fullest confidence. He sums up his opinion of the Babylonians shortly in the following words: "It is beyond doubt that, as early as the time of the philosopher Thales, the Chinese and Babylonians possessed observations extending over several centuries of the most striking celestial phenomena, and that through them their attention had been directed to the periodical return of corresponding eclipses after a cycle of 223 moons, or 18 years and 11 days, which they called Saros, and employed for making predictions." In the discussion of the "Most ancient views upon the system of the world" (p. 23) he says further: "While the Babylonians, Chinese, and Egyptians contented themselves with collecting isolated experiences, fixing certain periods, &c., and scarcely a trace of any scientific system whatever is to be found in their work, the ancient Greeks struck out an entirely different line."

Speaking of the Metonic cycle, a period of nineteen years, at the expiration of which the lunar phases return partially to the same hour, but sometimes with a difference of twelve hours, Wolf mentions indeed the Indians and Chinese, but not the Babylonians; to the latter he simply denies the knowledge of precession, and the difference between the sidereal and tropical years. The same scholar says, referring to the Zodiac[2]:—"To which ancient people the priority in this respect belongs, whether to Indians, Chaldæans, Chinese, or Egyptians, &c., we are to this hour ignorant, in spite of all that has been suggested, and of very extensive researches; and we shall perhaps never know, since all dates are too uncertain, and all representations too crude and inexact; and we are equally far from ascertaining from which people this knowledge, even though with some transformation, passed over to the Greeks. The Zodiac was certainly not invented by the Greeks, who at first possessed only eleven signs because, through a misunderstanding of what came to them from abroad, they threw Libra and the claws of Scorpio together." R. Wolf's work records nothing of the knowledge of the Babylonians about the courses of the planets; the scanty mention of them is too obscure and general.

So far the Cuneiform Inscriptions have not lifted the veil of darkness, but in one direction, with respect to observations, they have brought greater clearness. According to Dr. Kaulen,[1] the Babylonians had numerous observatories throughout the country which were specially fitted up for watching, and the observations must have been made regularly, for the astronomers had to send in their records at appointed times. Dr. Oppert[2] has examined and interpreted several astronomical reports of the Assyrians, and a few passages from one of them (the text is published in Rawlinson's "Cuneiform Inscriptions," vol. iii. plate 59, n. 9) are given here:—

"To the King, my lord, thy faithful servant, Mar-Istar."

"On the 27th day the moon disappeared. On the 28th, 29th, and 30th days we observed the moon's node of the eclipse of the sun: the time passed by: no eclipse occurred."

"On the first day, as the new moon's day of the month Thammuz declined, the moon was again visible over the planet Mercury, as I had already predicted to my master the King. I erred not."

"In the hour (kaš-su-ut) of Anu (Saturn[3]) she appeared at setting, in the circle of Regulus (chief of the heavenly host), but her track was not discernible in the mist of the horizon."

Even if observations of this kind were intended to serve astrological ends, they must also have helped to prepare the ground for astronomy, and that this ground was really trodden by the Chaldæans we have strong evidence in the tables which we have interpreted.

Before considering this point more closely, it might be well to answer the question, When does the recognition of a succession of natural phenomena become scientific?

Regular observation, with its corresponding record of such phenomena, certainly belongs to science, yet is not science in itself, but merely the necessary primary condition: science only begins when amongst these various forms the natural law comes to light. If the law discovered have such a firm and fixed form that it can be submitted, as it were, to a practical test, we have then to record a truly scientific victory. This practical test can, as a rule, be conducted in various ways according to the nature of the phenomena. If we are in a position to call into existence the conditions on which these phenomena depend, although on a smaller scale, then the law which has been discovered may be experimentally verified. Of course we must renounce the idea of experiment with regard to our celestial phenomena; but in its place another no less certain method is at our command. For instance, if the law of a planet's motion be discovered and completely ascertained, it must be possible to determine beforehand whereabouts in the ecliptic that planet will be found on a certain day.

We learn that the Babylonians applied these tests, and, considering the period, they accomplished them in a brilliant manner. With regard to the moon they were able to declare, not only the day of crescent moon, but also the time of her visibility on that evening, as well as the duration of visibility on the day of her disappearance. Their data for the risings and settings of the full moon are most satisfactory. As to eclipses, they did not confine themselves to their so-called Chaldæan period, for through this alone it would have been impossible to give the real visibility of an eclipse of the moon[1]; but the Babylonians determined the visibility, the hour, and the magnitude of the eclipse. They only once decidedly failed, when they announced an eclipse which never happened, or would certainly not have been visible in Babylon. Here, however, we may raise the question whether this failure should be attributed to the method employed or to an accidental miscalculation. The latter is the most likely, as in other data they are only guilty of comparatively small errors. They were well up in the paths of the planets. Their data for the heliacal risings and settings, for opposition, retrogression, and especially for the position of certain fixed stars, are within a few degrees of the reality. We can produce nothing similar from any other people of antiquity. We must, therefore, not neglect to rectify an error which, since the time of Biot, has appeared in books of history.

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[1] "Geschichte der Wissenschaften in Deutschland: Neuere Zeit. Geschichte der Astronomie," von Rudolf Wolf (Munich, 1877).

[2] *l.c.*, p. 188.

[1] *l.c.*, p. 172.

[2] "Die astronomischen Angaben der assyrischen Keilinschriften," von J. Oppert (1885).

[3] Dr. Oppert takes Anu for Saturn: we have proved that *An* is Mars.

R. Wolf also says in his "History,"[2] speaking of stellar co-ordinates:—"Even the ancient Chinese must have observed the culmination times of the stars by the help of their water-clocks, and, according to Biot, 28 stars distributed in the circle of the heavens (*i.e.*, in the ecliptic) served their purpose: they compared these stars again and again with each other as firm points of reference from which to determine the positions of the remaining stars, and especially of the planets. By the help of this practice—unchanged from time immemorial—they derived the periods of revolution of the sun, the moon, and the planets with great accuracy, ascertained the periods which bring these bodies into conjunction with, or opposition to, each other, &c. On the other hand, the Chaldeans, like the ancient Greeks, observed the horizon almost exclusively."

It was not the Chinese but the Chaldæans to whom the whole merit should have been given in the above quotation, and they have further the credit of having erected for themselves, with the help of these normal stars, a scientific edifice of astronomy which suggested to them the means of announcing, for future times also, the places of the planets almost to a day. It is remarkable that here exactly 28 normal stars are spoken of, a number corresponding to their 28 constellations; yet it is unlikely that the Babylonians should not have also selected one or another star in the neighbourhood of the ecliptic, in Aquarius, or in the beginning of Pisces, even if of lesser magnitude, the more so as they made use of all twelve signs of the Zodiac for determining the positions of the planets at their heliacal rising and setting.

It might appear striking that the observations of the sun are scanty, and that even the direct ones appear somewhat faulty. As an instance, the autumnal equinox is correct with regard to the position of the sun, while the vernal equinox and the summer and winter solstices are not correctly indicated astronomically. We have already remarked that this deviation was probably intentional, in order to divide the year into equal parts. Moreover, the Chaldæans must have been very familiar with the path of the sun, since that was the first condition of being able to indicate accurately, as they did, the constellations for the planets and the Sirius phenomena. These two tables do not admit of any positive conclusions as to the accurate knowledge of the tropical year and the difference between it and the sidereal year, or of the retrogression of the vernal point: we ought to possess others more remote by some centuries than the above-mentioned ones.

Though we may only answer it by conjecture, we cannot dismiss the question which forces itself upon us here—namely, How did the Babylonians contrive to foretell the positions of the moon and the planets? They must have had some sort of theory concerning the movement of the moon, for we find a completely developed mechanism of calculation through which they developed the new moon from the preceding one, so that they were able to fix the time of crescent moon and its first quarter. Unfortunately we are unable to submit these calculations to a practical test because we do not know to what year they refer: but we can see from the whole process, and from the results of our three tables for the years 188, 189, and 201 S.E., that they accomplished what was possible at that time.[1]

With regard to the planets we find ourselves in a somewhat difficult position. The beginning of an explanation is, however, offered by another class of tables which contain the positions of single planets in detached sections. We have before us two of these tables, the copies of which Father Strassmaier had the kindness to transmit to us. The first (now published in the *Assyriological Journal* of Dr. Bezold, vol. v. p. 341 ff., marked R^{m} 678) is from the Rassám collection in the British Museum, and contains all the planets, but each for a different year, the other was acquired last year by the American expedition of Pennsylvania University through Prof. Harper. The British table, which we have examined to some extent, contains, especially in the new copy, sufficiently clearly Jupiter (even for two years), Venus, Mercury, and Saturn—of course with few data; on the other hand, the data for Mars are for the most part damaged, but the year is visible with sufficient data to allow of its verification.

The deciphering of both tables of ephemerides first justified the wish to elucidate the matter, for the knowledge of these alone afforded a well founded hope of revealing the partially analogous text of the others. Before attempting such a task, however, it should be established why, in the case of these last, different years for the different planets should be found together on the same tablet. This important association must have had some object beyond the scope of the tablet, because the positions of the planets are by no means in accordance. It was not far to the thought that, because the planets also have periods in their apparent paths, all data together should build up the foundation for the ephemerides of a coming year. Upon this supposition it was not difficult to determine the single years. Venus, for instance, had a period of 8 years, at the expiration of which the same apparent positions returned approximately. We will now place before the reader the years which are given for the individual planets (according to the era of the Seleucidæ), and below them the periods corresponding to those planets; which then, added to the number of the year, must in each case give the same year of that era, if the above view be correct.

Venus	228	Mercury	190	Jupiter	224	Saturn	177
Period	8	Period	46	Period	12	Period	59
	236		236		236		236

The agreement is so striking that no doubt the planetary data of these years have been used for the ephemerides of the year 236 S.E. How the transition was effected can only be recognized if for instance the ephemerides of the year 236 S.E. should be discovered.[2]

The American tablet is similarly constructed. On it the data for Saturn and Mars are completely broken off, but it contains a few more lunar dates, with the addition of the year 225 S.E., for which the combination is calculated. Jupiter is represented in this and the English one by two whole years, the one corresponding to the period 12, the other to one of 83 years, where above in the English tablet the number of the year is broken off.

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[1] The lunar eclipse of the 2nd of August, 123 B.C. (*i.e.* −122), was 18 years before so small (magnitude 0·1 digit), that it can hardly be considered as having happened at all, the more so as the time was unfavourable for Babylon, being broad daylight.

[2] *l.c.*, p. 155.

[1] Compare J. Epping's interesting article "Die babylonische Berechnung des Neumondes" ("The Babylonian Calculation of the New Moon") in the *Stimmen aus Maria-Laach*, vol. xxxix., September 1890.

[2] In the meantime, these ephemerides of the year 236 S.E. have been found in the treasures of the British Museum, and the Rev. Jos. Epping is engaged in making the necessary calculations.

A preliminary investigation makes it appear probable that we have to deal with the results of observation in both tablets. The longitudes calculated for Venus, for instance, according to the lists of dates given in the tables, differ as a rule in minutes only from the longitude of the annexed normal star, and differ always least when the latter is not far from the ecliptic, and consequently the agreement in longitude would be easiest to observe. It is further remarkable that in these cases the negative difference between ♀—✳ is the predominant one, as though the results which we receive from Le Verrier's tables for the geocentric positions of Venus were about 10′ too little. This stands out still more clearly in the case of the more scantily represented constellations of Mercury; here the negative difference rises to 1°.

The above-mentioned table of the 7th year of Cambyses (published in the *Assyriological Journal* of Dr. Bezold, vol. v. p. 281; and by Dr. Oppert, "Un Annuaire Astronomique Chaldéen, utilisé par Ptolémée," *Comptes rendus des Séances de l'Académie des Sciences*, tome cxi., séance du 17 novembre 1890; cf. Almagest, book v. ch. 14) contains no constellations at all of planets with fixed stars, but only data for the relative[1] positions of the planets, and may accordingly bring us further knowledge of their relative position at that time. This table is of greater importance for the path of the moon. The data for the time of eclipses are of less value, since their accuracy goes only to a half or a third *kas-bu* (= double-hour).

On the other hand, the data for the rising and setting of the full moon in a given case are to be estimated at a higher value. We have in this tablet clear and distinct data, for at least ten months, as to how many degrees of time before sunset the moon rose (1° = 4m.). As further subdivisions to one-sixth of a degree are given, and the observation and measurement of the slightest difference in time at the time of full moon hardly admit an error of more than 1m., the position of the moon with regard to the sun may be determined with an unusual degree of accuracy. This might raise the hope that the work of the Chaldæans might benefit even our advanced age. In the meantime it may suffice to have won again for the old astronomers the place of honour in science which was accorded to them in ancient times.

Chronological Summary.

The learned chronologist Ideler gives a convincing testimony[2] to the uncertainty which still reigned in the first half of our century with regard to the Babylonian chronology. He says, "Nowhere do we find peculiarly Chaldæan months, and in no author do we find the years reckoned according to a Chaldæan era. We shall therefore only be able to answer conjecturally the question, Of what nature was the Chaldæan chronology?"

As much may have been made clear in this domain since Ideler's time, it will be interesting to bring together the results which have been rendered certain through the interpretation of the Cuneiform Inscriptions.

First, the era of the Seleucidæ has acquired a firmness such as appertained to hardly any other before the Christian era. The data given in the tables for the years 189 and 201 S.E., indicate a unanimity of astronomical phenomena which can only belong to the years − 122 and − 110, and indeed with such an exclusiveness as would hardly allow of the recurrence of such a combination within a period to be measured by thousands of years. The Seleucidæan era is combined with the Arsacidæan in these tables, so that we are now able to determine both with equal certainty.

We have

− 122 = 125 Arsac. E. = 189 S.E.

therefore

− 246 = 1 ,, = 65 ,,

and

− 310 = 1 ,,

Ideler distinguished a double Seleucidæan era, a Chaldæan, and a Syro-Macedonian[1]; he made the former begin in the autumn −310, the latter in autumn −311. Dr. Eduard Mahler[2] also places the beginning of the latter in the autumn of the year −311. If we put aside Ideler's first statement, then both scholars agree with our results, but the beginning of the year is to be placed six months later in the tables in question; therefore 1 S.E. = −310. The difference in the beginning of the year may be further explained through other inscriptions. Father Strassmaier has published some Arsacidæan inscriptions in the *Assyriological Journal* (vol. iii.), and amongst these the 11th (p. 137) begins—"Sanat 170 kan Di-mit-ri-su arah Adaru," &c. Then follows "Arah Airu 14 na," without the year's number suffering any change; therefore the year 170 of Demetrius began before the month Adar, with that of Thischri—that is to say, in the autumn. The table contains a horoscope, and gives constellations for the night of the 6th Adar which suit so exclusively for the 28th February −141, that they could hardly appear again in their entirety for 200 years before or after. It follows of itself that the year of the horoscope has not been reckoned from the beginning of the reign of one of the known Demetrius. As, on the other hand, 170 S.E. is −141 (that is, 142 B.C.), it follows that the tablet is dated according to the Seleucidæan era, but with the beginning of the year in the autumn, for which reason, perhaps, Demetrius is inserted as a distinguishing point.

Perhaps the first-named view of Ideler, that a Chaldæan era existed which began exactly a year later than the Syro-Macedonian, should not be dismissed simply with a wave of the hand. Certainly, no direct evidence can be produced in support of it, but we can advocate the grounds of probability. Father Strassmaier, speaking of the fourth of the above-mentioned inscriptions,[3] remarks: "We learn with certainty from the double dates of the inscription that the year of the Arsacidæan era began with the month Thischri, while the Seleucidæan began with the month Nisan: for it is only in this way that the above figures can be understood; the month Tebeth of the year 152 is the year 216, and the month Thammuz of the year 152 is the year 217 of the Seleucidæan era." Seeing, then, that there is the same difference—64—between 152 and 216 as in the data of our first planetary table—125 equal to 189—in the case of the new year being given with Nisan at the head, 124 equal to 189 should be written. Hence it follows that the Chaldæans made the Arsacidæan era begin half a year later than the Seleucidæan. It is not impossible that the Chaldæans, in order to bring both years into harmony, put off the beginning of the year from spring to the following autumn, and this becomes probable in case of Ideler's view having positive foundation.

Two difficulties which Dr. Oppert[4] advances against the Seleucidæan and Arsacidæan eras are removed by our tables. Firstly, he agrees with Dr. Mahler, and consequently with us, that the Seleucidæan era begins with the year − 311, but holds that this era can only be supposed in question when the name of Seleukos is recorded. This objection is instantly refuted by the tables before us, and also by two others, No. 9 and No. 11, published by Father Strassmaier in the *Assyriological Journal*, for in them the era is not named after Seleukos. Besides this, there exist some unpublished tables in which the same thing occurs; and yet, as above, the years are certainly reckoned according to the Seleucidæan era. Dr. Oppert feels justified in assuming further that the Arsacidæan era begins with

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[1] The calculations prove that these dates are based on observations; here Mars is called Ni-bat-a-nu, and Jupiter Sag-me-ša, or Sig-me-sa.

[2] "Handbuch der mathematischen und technischen Chronologie," von Dr. Ludwig Ideler, vol. i. p. 202.

[1] *l.c.*, pp. 223 and 224.

[2] "Chronologische Vergleichungstabellen," 1 Heft, von Dr. Eduard Mahler.

[3] *Zeitschrift für Assyriologie*, vol. iii. p. 132.

[4] *Comptes rendus des séances de l'Académie*, tome cvii. pp. 467 and 468.

1 Arsac. E. = −255 in the autumn.

He applies it in the translation of the already-mentioned Strassmaier inscription, No. 9, which contains the course of an indicated eclipse[1] of the moon. Yet if we look at the year's data in this table, we shall easily find that they agree with our own. The text runs as follows:—"Šanat 168 kan ša ši-i Šanat 232 kan Ar-ša-ka-a." It is, as we see, completely analogous to those of 189 and 201 S.E., and the difference 232 − 168 is again exactly 64. Accordingly, in this table (No. 11) apart from its contents, the eras are none other than the Seleucidæan and the Arsacidæan.

The determination of the eras in use in Babylon at the time of the Macedonian rulers, will always be fraught with some difficulties which may be more easily and confidently disposed of if astronomical data are dated according to such an era.

The years in our Seleucidæan era are so-called "bound"[2] lunar years. We know that the Babylonians had lunar months—some of 30, some of 29 days—whose number was not determined according to the mean new moon, as was the case with the Greeks, but was reckoned from the crescent moon, in close connection with the real new moon. If they wished, with regard to the number of months in the year, to remain in harmony with the solar year, they would have been obliged to fix on an average in 11 years—7 years with 12 months, and 4 with 13 months.

Like the Jews to the present day, they had intercalary months, but without intercalary days in addition. The lunar year of the Chaldæans was so vigorously defended by Fréret that even Ideler, who preferred to attribute the Egyptian year to the Babylonians, could not do otherwise than pronounce Fréret's hypothesis probable. Yet here he differed from Fréret's view in that he could not bring himself to attribute to the Chaldæans an "unbound" year—that is to say, a year of 12 lunar months. He did not dispute the *saros*, *neros*, and *sossos*[3] of the Babylonians, but he denied that these great periods were the only means through which a connection with the solar year could be restored. Ideler was, if one ascribes lunar months to the Babylonians, absolutely in favour of the "bound" lunar year. In this he has remained perfectly right. The Babylonians had real intercalary months, as we have seen, in the case of the year 189 S.E. The many inscriptions which Father Strassmaier has published testify for other years. We refer the reader to his "Nabonidus," in which the 1st, 3rd, 6th, 12th, and 15th years had a second Adar, and the 10th had further a second Elul.

The fact is therefore established, but what was the nature of the intercalation? Had the Babylonians a fixed law for it, or did they allow a choice to be made in the single years within certain periods, for instance of eleven years? The latter appears so far the most probable, for, in the event of a fixed law, two intercalary years could hardly ever follow each other, and yet we do find such cases in the communications of Father Strassmaier, although very rare and perhaps uncertain: the years 2 and 3 of Cyrus, and 11 and 12 (?) of Darius were intercalary. Dr. Oppert is also of the opinion that the intercalation has been very arbitrarily accomplished. It would seem as though the Babylonians must have found themselves in no less a dilemma from the putting back of the date some few decennaries, unless official lists of all successive months and years were strictly kept. Even if this be assumed, Ideler's objection still subsists,[1] "that they must have had a well organized chronology: otherwise how could the Greek astronomers, to whom their observations served as a foundation for a theory of the moon, have accepted their data with so much confidence?" Certainly Ideler's view, which in his time was the most general, that the Chaldæans had no era of their own, but used the Egyptian, or at best reckoned according to the moon for civil life, is, as we have seen, falling into disfavour. Our tables are of an astronomical nature, and only permit an intimation of Egyptian chronology, in the Sirius phenomena, to glance through.

Moreover, the above-mentioned opinion requires but a slight modification of form in order to appear not only acceptable, but probable. We might be led to suppose that the astronomers made use of a double chronology, one which had its foundation in the movement of the moon, another which was in accordance with the path of the sun. Otherwise how could they have determined beforehand, within a few degrees, the exact position of the planets, even of Mercury? They must have been very familiar with the length of the solar year, and probably referred their calculations first of all to a solar year of some organized form in order to transfer the results afterwards to the lunar year.

Unfortunately we possess no documents which might afford us a positive insight into the matter. With regard to the beginning of the year we have already shown that the Seleucidæan era, as it is presented in our three tables, began the year with the month Nisan, therefore in spring. It would appear that in this an old tradition was held to, for in the inscriptions published by Father Strassmaier from the reigning years of Nabonidus and Nabuchodonosor we have an accession year[2] in each case.

In the first the year extends from Sivan beyond Thischri to Adar; in the latter Thammuz[3] is evidently represented, including Thischri and Kislev, so there is full evidence that Thischri, and consequently the autumn, did not form the beginning of the year. If, then, founding the commencement of the Babylonian year[4] in the month Nisan, we postpone it to spring, we cannot well go too far.

The transference to Thischri or autumn was probably a consequence of the Macedonian rule, for the Macedonians celebrated the beginning of the year in the autumn, and, previously to the Arsacidæan era there is no inscription known which places the new year in Thischri.

If we knew the beginning of the year of all the eras in use in those times, the exact determination of date of any data might still be a matter of difficulty, because the beginning point[5] in a "bound" lunar year is always uncertain. In the first table (189 S.E.) the 1st of Nisan fell on March 25; in the other one, of 201 S.E., on April 10; and in others the variation may be much greater.

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[1] A translation of this description of the lunar eclipse is to be found in the *Assyriological Journal*, vol. iv. p. 76, which still holds good against the objections of Dr. Oppert, *l.c.*, p. 174.

[2] The lunar year is *bound*, when it is kept in harmony with the solar year by intercalation; *unbound*, when it contains always only 12 months, so that the beginnings of the lunar and solar year coincide only after long periods, as in the Muhammadan era.

[3] There are many different opinions about these periods: some say *saros* = 3600, *neros* = 600, and *sossos* = 60 years; others only so many days; again, some think, and perhaps with greater probability, that *saros* signifies the Chaldæan period of 18 years and 11 days, but then they are uncertain about the meaning of *neros* and *sossos*.

[1] *l.c.*, p. 202.

[2] An accession year contained the rest of the months of the current year, whenever the beginning of the reign of a new king fell in the current year.

[3] Compare the inscriptions of Nabopalassar in the *Assyriological Journal*, vol. iv. p. 121, n. 19.

[4] Dr. Oppert, in his "Chronologie Biblique," pp. 11 and 12, puts the beginning of the Assyrian year in general in Nisan, but for weighty reasons he fixes the beginning of the eponym year in Thischri or in the autumn: "les éponymies vont de Thischri à Elul, et non de Nisan à Adar."

[5] E. von Herdtl, in his "Astronomische Beiträge zur assyrischen Chronologie," p. 43, thinks that the beginning of the Assyrian year falls on the first new moon before the vernal equinox.

It is only when astronomical data are combined with Babylonian dates that we can hope to determine the corresponding Julian date.

Another similar question which chronology has to answer is, whether the change of date was reckoned according to a point of time, or according to the civil day. According to the evidence brought forward by Ideler, the ancients were convinced generally that the Babylonians reckoned the day from one sunrise till the next, and therefore made the change of date take place in the morning. Ideler finds a difficulty here, in that such a supposition would hardly be compatible with a chronology depending on the changes of the moon. We must allow that he is right, and we think we have sufficiently proved that the first day of each month coincided with the first visibility of the crescent moon. Whether the Babylonians were first prompted by the Macedonians, at the outset of the Seleucidæan era, to put off the date till evening, cannot be learnt from the documents, but it is not probable, if we disregard Pliny, Censorinus, &c., for they reckoned in lunar months earlier. If we honour these historical statements as we are bound to do, there is yet a kind of explanation to be offered.

We have seen that the Babylonians referred their calculations for the new moon to midnight, so that astronomically speaking the change of date was accomplished at this hour, so it is not impossible that they did not forestall the civil day, but let it succeed the astronomical. This is nothing but a conjecture, in order not to reject the authority of the ancients.

The last chronological element upon which we have to speak is the division of the day. It is generally accepted that the Babylonians cut up the day into twenty-four hours—twelve day and twelve night hours. There is so much evidence here that we cannot doubt the fact. Our tables show another division which was in use among astronomers. It is completely demonstrated in the calculation tables, where the whole day is split up into six divisions, and each division into sixty subdivisions, so that the whole day falls, like the circle, into 360 parts, of which one equals four of our minutes. For the sake of calculation, the subdivision is carried on to sixty, and yet another sixty. The application of this method of calculation shows itself also in the ephemerides, first of all to express the duration of visibility with regard to the moon, and also to declare the time when, according to calculation, an eclipse should happen. It is remarkable that we have here two starting-points, sunrise and sunset; while in each case it is announced how many degrees of time before or after these terms the eclipse will happen. The extreme points, therefore, for both then touched at midday or midnight.

TEMPERATURE IN THE GLACIAL EPOCH.

THE late long frost has naturally suggested the question, What permanent fall of temperature would produce a recurrence of the Glacial epoch? It is a question not easily answered, for it is like a problem complicated by too many independent variables. It is not enough for us to ascertain the actual temperature of a district in order to determine whether it will be permanently occupied by snow and ice. There are regions where the ground, a short distance below the surface, is always frozen to a depth of several yards at least; and yet glaciers do not occur, even among the hills, because the amount of precipitation is so small that the summer rapidly dissipates what the winter has collected. There are other regions partly covered by ice though their mean annual temperature is distinctly above the freezing-point; as where glaciers descend to the sea from hilly districts, of which a considerable area lies above the snow-line, and on which there is much precipitation. In the case of Great Britain, at least, a further difficulty enters into the problem—namely, that much controversy still prevails as to the interpretation of the symbols upon which our inferences in regard to the temperature of these islands during the Glacial epoch must depend. Some authorities would concede no more than that the highland districts of Scotland, Wales, and England were enveloped in snow and ice, and the glaciers, whether confluent or not, extended from their feet for a few leagues over the lowlands—say, to some part of the coast of Lancashire and of Northumberland; while others desire to envelop a large part of the British Isles in one vast winding-sheet of ice, a corner of which even rested on the brow of Muswell Hill, above the valley of the Thames. The one school regards the Boulder Clay of England as a deposit mainly submarine, the product of coast-ice and floating ice in various forms; the other attributes it exclusively or almost exclusively to the action of land-ice. Into this thorny question we do not propose to enter. The approximation which we shall attempt—and it can only be a rough one—can be easily modified to suit the requirements of either party.

We will assume throughout that the annual isothermal of 32° coincides with the line of permanent snow. This, obviously, is an assumption; often, owing to small precipitation, it will be found to be erroneous, but we take it as the only simple approximation, for, under favourable circumstances, masses of ice may protrude beyond it.

The question, then, may be put in this form. Assuming a sufficient amount of precipitation, what changes of temperature are required in order to bring within the isothermal of 32° regions which are generally admitted to have been occupied by land-ice during some part of the Glacial epoch?

First, in regard to the British Isles. All will admit that in many places the Cumbrian and Cambrian glaciers descended to the present sea-level. The mean temperature of the Thames Valley near London is 50° F. This isotherm cuts the Welsh coast a little east of Bangor. Obviously, the whole region north of this line has a lower mean temperature, no part of the British Isles, however, being below 45°. Hence a general fall of 18° would give a temperature of 32° at most in the Thames Valley and on the shores of North Wales (except on the extreme west), while on the coasts further north the temperatures would range down to 27°. What would be the effect of this? Switzerland may enable us to return an answer. The snow-line in the Bernese Oberland may be placed roughly at 8000 feet above the sea, but it is obvious that the chief feeding-ground of the Alpine glaciers lies rather higher up in the mountains. In the case of such glaciers as the Great Aletsch, or the Aar, the lowest gaps in their upper basins are rather above 10,000 feet, while the surrounding peaks range, roughly, from 12,000 to 14,000 feet, though but few exceed 13,000 feet. Thus the feeding-ground of the Oberland glaciers may be regarded as equivalent to a mountain district the sky-line of which ranges from rather above 2000 to 5000 feet. In reality, however, not very much of it exceeds 4000 feet above the snow-line. This, indeed, rather overstates the case. We find practically that the effective feeding-ground, that which gives birth to glaciers, which protrude for some distance below their supply basins, may be placed about 1000 feet above the ordinary snow-line; so that the glacier-generating region of Switzerland may be regarded as equivalent to a mountain district with passes about 1500 feet, and peaks not often exceeding 3000 feet. It follows, then, that if the temperature at the sea-coast in North Wales were 32°, the whole of the Scotch Highlands, and a large part of the Cumbrian and Cambrian Hills would become effective feeding-grounds, and the glaciers would be able to descend into the plains. In the Alps, the larger glaciers terminate at present at altitudes of from 4000 to 5500 feet (approximately); that is, they descend on